

A 768-channel detector for photoelectron spectroscopy using synchrotron radiation

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Introduction

Photoelectron spectroscopy is a technique that provides a wealth of parallel information and can be applied to a wide range of materials. For example, it is widely applied to semiconducting materials to monitor changes in surface composition, electronic structure, interface energetics, interface bonding and thin film growth [1]. By combining the intense light of a synchrotron radiation source with efficient detection of electrons, it is possible to apply the photoelectron spectroscopy technique with sufficient time resolution to study the dynamics of surface processes in-situ. A fully integrated detector has been developed at the University of Wales, Aberystwyth that enables rapid and efficient collection of photoelectrons [2]. Device performance in the first photoelectron spectroscopy measurements using soft x-ray excitation at the SRS, Daresbury laboratory is reviewed and the application of the combined detector/analyser system to real-time monitoring of surface processes is described.

The UWA multichannel detector

The UWA multichannel detector array comprises a custom ASIC mounted on a ceramic substrate in proximity to the rear face of an MCP. The ASIC contains 768 channels, or pixels, each measuring $3\text{mm} \times 18\mu\text{m}$ on a pitch of $25\mu\text{m}$. Each channel has a metal anode to collect the electrons as they emerge from the MCP; a charge sensitive amplifier to produce a digital signal in response to the electron pulse and an 16-bit counter associated with it to accumulate the counts as they arrive and circuitry to read out the data sequentially from all channels in the array. Each pixel on the ASIC has a trigger threshold of approximately 2×10^5 electrons from the MCP, adjustable by means of a sensitivity control. The MCPs fitted to the detector were a pair of custom sized Hamamatsu plates with $12\mu\text{m}$ pores, similar to the F2370 design, arranged in a chevron configuration.

The detector assembly was mounted at the focal plane of a VG CLAM4 hemispherical analyser, replacing the conventional channeltron detector enabling operation in scanning mode or fixed kinetic energy (snapshot) mode [2].

Initial testing offline at Aberystwyth and at SRS 4.1 showed a detector noise floor of 3.7×10^{-4} counts s^{-1} pixel $^{-1}$. The maximum count rate was determined to be in excess of 2×10^4 counts s^{-1} pixel $^{-1}$ [3].

Real time study of thin film growth.

The detector/analyser combination was used at SRS MPW 6.1 to study the deposition of an organic semiconductor, tin phthalocyanine (SnPc), on a clean polycrystalline gold surface. A survey spectrum of the clean gold surface was taken using the detector in scanning mode. By analysing the survey spectrum and recording detailed swept spectra at selected emission regions the focal plane of the analyser was calibrated in eV per pixel and correction factors to reduce non-uniformity in the detector and analyser determined. Working at a pass energy of

100 eV, the detector was determined to occupy a spectral range of approximately 6 eV.

The analyser control software was set to take snapshot spectra at several regions of interest during deposition. Snapshots were taken of the Au4f, Au5p and Sn4d regions of the emission spectrum with an integration time of 1s. Snapshots were taken of the region in the vicinity of the Fermi level with an integration time of 10s. A small delay was introduced between successive snapshots to allow the analyser to stabilise. The sequence of snapshots was repeated as the organic thin film was deposited on the gold surface to generate a real time sequence of spectra for both substrate and overlayer emission peaks. A 3D plot of the snapshot sequence comprising some 350 spectra corresponding to the Au4f region is shown in Fig 1. The peak attenuation suggests Stranksi-Krastanow growth.

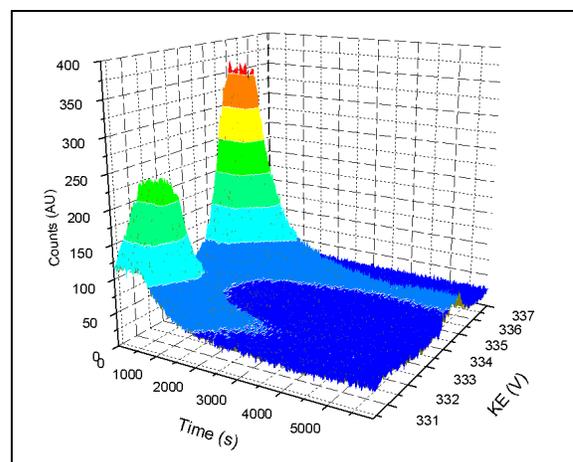


Fig.1. Evolution of Au4f peaks during deposition of SnPc

Acknowledgements

This work was funded through the EPSRC Real-time Electron Energy Spectroscopy (REES) programme (GR/R08575, GR/S74126). Access to the SRS was funded by the CCLRC. Support provided by National Assembly for Wales Centre for Advanced Functional Materials and Devices.

References

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